Int. J. Sci. R. Tech., 2025 2(3)
A Multidisciplinary peer-reviewed Journal
www.ijsrtjournal.com [ISSN: 2394-7063]

Original Article

Callosobruchus Maculatus: A Biotic Enemy to Pigeon Pea Productivity

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ABSTRACT

The cowpea (pigeon pea) weevil, *Callosobruchus maculatus*, is a significant pest of stored pulses, particularly affecting crops like cowpea and pigeon pea in tropical and subtropical regions. This review examines the biology, life cycle, and the damaging effects of *C. maculatus* on stored pigeon pea grains. The insect undergoes a holometabolous life cycle, with rapid development influenced by temperature and humidity, which allows for multiple generations during a single storage season. The damage caused by *C. maculatus* includes direct feeding on seeds, resulting in weight loss, reduced seed viability, and compromised nutritional quality, along with contamination from insect frass and remains, further degrading the grains' marketability and safety. The economic impact is substantial, particularly in regions where pigeon peas are a staple crop, affecting food security and farmers' livelihoods. Control measures for *C. maculatus* include a combination of cultural, physical, chemical, and biological strategies. These include proper storage practices, the use of inert materials like diatomaceous earth, irradiation, low temperature treatments, and chemical controls, each with their advantages and limitations. Integrated pest management, utilizing multiple strategies, is essential for effective control and minimizing losses.

Keywords: *Callosobruchus maculatus*, Pigeon pea, Stored grain pests, Pest control, Crop damage

INTRODUCTION

The cowpea (pigeon pea) weevil, *Callosobruchus maculatus* (Fabricius) is a major pest of stored pulses, more specifically the cowpea and pigeon pea. This insect is of the order Coleoptera, Chrysomelidae family, and Bruchinae subfamily. Also referred to as the cowpea weevil or cowpea seed beetle, it is a global bug that results in considerable crop losses of stored legumes in the tropical and subtropical climates as noted by Akbar *et al*. (2022). Adult *C. maculatus* beetles are small in size and are usually between 2.5 to 3.5 millimetres in length (Magaji *et al.*, 2020). They have a very unique brown fur with black and grey markings. Elytra (wing covers) are especially distinctive; they are coloured black with large spots also helping to identify the species. The insects are sexually dimorphic, where the females are slightly larger than the males. The antennae are grooved and are segmented into 11 different sections which is a distinct feature of the species (Salunkhe & Gaikwad, 2023).

Figure 1: Mature Male and Female Pigeon Pea Bruchid (*Callosobruchus maculatus*). Adapted from Ethan Estabrook, BCE-Research Associate at Insects Limited

2.0 Life Cycle of *Callosobruchus maculatus*

C. maculatus undergoes holometabolous development, characterized by complete metamorphosis through four distinct stages: These stages are the egg stage, larvae stage, pupal stage, and the adult stage (Salunkhe & Gaikwad, 2023). The

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overall development time depends on the environmental conditions in terms of temperature and humidity.

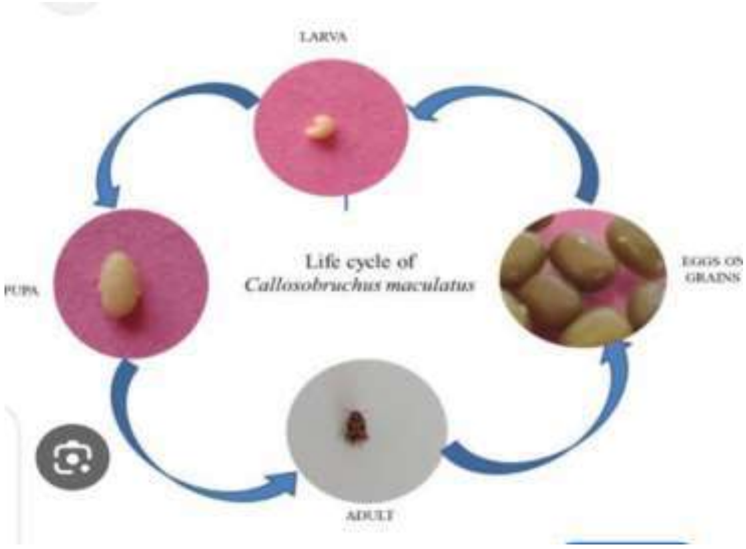

Figure Error! No text of specified style in document.**.1: Life Cycle Model for *Callosobruchus maculatus*. Adapted from ScienceDirect.com**

2.1 Oviposition of *Callosobruchus maculatus*

Female *C. maculatus* beetles deposit eggs on the outer surface of the seeds or pods of the host plant. They are small, oval shaped and can easily go unnoticed; they measure about 0.6 mm in length and are initially transparent but become translucent (yellowish-white) with time. The eggs are tightly attached to the seed surface so that the emerging larvae are in a direct contact with their food. A single female lays 120-132 eggs during its lifetime (Salunkhe & Gaikwad, 2023). Mating behaviour has been documented and coupled females are known to preferentially oviposit on large smooth seeds.

2.2 Larvae Development of *Callosobruchus maculatus*

The life cycle of *C. maculatus* consists of four instars. The first instar larva emerges out of the egg shortly after hatching and penetrates the seed while the empty egg case is left on the seed surface. Later embryonic development takes place only inside the seed, while the larva feeds on the cotyledons and embryonic tissues. The feeding that occurs internally affects the quality and viability of the seed by causing severe damages to it. The larval development period normally ranges between 2-3 weeks but may vary with different conditions such as the quality of the seeds in which the larvae are feeding on (Salunkhe & Gaikwad, 2023).

2.4 Pupation of *Callosobruchus maculatus*

Pupation period of *C. maculatus* takes place within the seed, with the mature larva forming a chamber near the seed coat. The pupa stage is exarate, thus, its appendages are visible and not confined to any body part of the insect. The duration of the pupal stage is about 4- 5 days under favourable environmental conditions (Salunkhe & Gaikwad, 2023). The adult weevil bores through the seed coat while developing and makes a round exit hole usually the first sign of infestation in stores seeds.

2.5 Generation Time of *Callosobruchus maculatus*

The generation time of *C. maculatus* is influenced significantly by environmental factors, primarily the temperature and relative humidity. The length of time that these creatures take to mature and complete their life cycle is relatively short, depending on the environmental conditions; where temperatures are about 30°C and relative humidity at 70% the cycle may take only about 25-37 days from egg to adult stage (Dipchansingh & Khan, 2021). This rapid development rate also enables it to have several generations within the same storage season making it dangerous to food produce.

3.0 Damage Caused by *Callosobruchus maculatus* to Pigeon Pea Grains

The effects of *C. maculatus* infestation on stored pigeon pea grains are complex and potentially destructive. The damages can be categorized into several types: direct feeding damage, contamination and quality degradation. Larval feeding is the primary form of damage. As larvae grow in the seeds, they feed on cotyledons, embryo and other body parts of seeds. The destruction leads to weight loss of the infested seeds and reduced seed viability. The protein content is also affected along with the distortion in the profile of essential amino acids in seeds reducing its nutritional value (Hajam & Kumar, 2022). Seed viability and seedling development also face huge challenges and heavily infested seeds often fail to germinate. The presence of adult insects, larvae, eggs, as well as the pupal cases in stored grains leads to contamination. Also, the cast ashes, insect frass (excrement) and exuviae (shed skins) poses an added lead in degrading the quality of grains (Ferreira *et al.*, 2021a). This contamination not only lowers the market value of the grains but also has implications to the health of consumers. The metabolic activities of the insects within the seeds create enhanced free fatty acids content and changes in protein composition. These biochemical processes alter the taste, smell and the general quality of the grains (Mahapatra *et al*, 2019). In severe infestations, the grains are often rendered unsuitable for human consumption due to the damage caused by the infesting insect. The damages can be severe, including the possibility of a complete loss of stored grain, if no adequate measures are taken within a few months of storage. Weight loss may be more in cases of severe infestations (Demis & Yenewa, 2022). The loss due to the damage caused by *C. maculatus* is greatly noticeable economically. It comprises lower market value due to physical damage and contamination, loss of seed viability whereby farmers spend more since the initial seed is not viable for planting the next season, and increased pest control measures and storage management which entail extra costs (Demis & Yenewa, 2022). In regions where pigeon pea is a staple crop, these losses can have significant implications for food security and rural livelihoods. The severity of damage is affected by factors such as the period of storage where longer periods cause increase of generations and therefore losses are possible, storage conditions-temperature and humidity, initial population density, and moisture content of grains (Mahapatra *et al*, 2019).

4.0 *Callosobruchus maculatus* Control Measures

Pigeon pea (*Cajanus cajan*) and other crops' pests' control, especially in stored grains, includes a combination of techniques. These techniques can be grouped under cultural control, physical control, chemical control, microbial control, biotechnical control, and botanical control. The techniques have their merits and limitations and pest management is usually most effective when several techniques are used.

4.1 Cultural Control

Cultural pest control involves a process of manipulating the factors that surround agricultural practices with the aim of reducing pest menace. These methods are mostly preventive and can go a long way in minimizing pest menace where and when carried out appropriately. For stored products such as pigeon pea, cultural control could, therefore, involve proper harvesting methods that do not harm the seeds, proper cleaning of the storage structures and constant monitoring of the environment to ensure that it does not encourage pest invasion. Other cultural management practices include crop rotation, intercropping, and planting dates since they are capable of interrupting the life cycle of pests and thus reducing their population in the field (Hajam & Kumar, 2022). For instance, intercropping pigeon pea with plants non-host to the pest such as *Callosobruchus maculatus* means the buildup of the pest's population during the growing season would be inhibited hence resulting to decreased initial infestation at the time of harvest.

4.2 Mechanical Control

Physical pest control entails methods which either cause the death of pests, or incapacitates them or hinders them from reproducing. These methods are particularly preferred due to their relatively innocuous effects on the environment besides not leaving chemical traces on the treated commodities.

4.3 Use of Inert Materials

Similarly, encasement with materials that are inert like diatomaceous earth, silica aerogels and kaolin clay can control storage pests like *C. maculatus*. These materials act through wearing the cuticle, consequently causing desiccation. For example, Öztekin and Mutlu (2020) observed that Ankara diatomaceous earth at a dosage of 600 ppm can kill *C. maculatus* adults in 7 days of exposure at 25°C.

4.4 Irradiation

Pest control using ionizing radiation with emphasis on gamma radiation has been used in stored product protection. Irradiation can kill or inhibit the development of insects, thus interrupting the life cycle of the pest. However, high initial cost and some consumer backlash to irradiated foods have kept it mainly a minor use (Indiarto & Qonit, 2020).

4.5 Hermetic Technology (Controlled Atmosphere)

Hermetic storage refers to a type of storage where the atmospheric characteristics within the storage area are manipulated. When insects breathe, they take in oxygen and releases carbon dioxide, making the atmosphere unfavourable for their existence. Other preliminary studies have shown that hermetic storage could reduce *C. maculatus* in cow pea, a related species to pigeon pea, without deleterious impacts on seed germination capacity (Demis & Yenewa, 2022).

4.6 Use of low temperature (Freezing)

Cold treatment is another control technique that involves exposing infested grains to very low temperatures which helps in controlling storage pests. Freezing can alter insect metabolism and growth. Low temperatures are not ideal for the growth and development of insects and above and below the optimum temperatures, the insects are not active that they slow down their growth and continue to die. Such temperatures applied continuously and at corresponding levels may be fatal to insects at all their developmental stages (Demis & Yenewa, 2022). However, costs of energy used for this process can be very high, particularly in large-scale production.

4.7 Dry Heat Treatment and Storage in Fire Place

Heat treatment is carried out by heating infested grains at a certain temperature for a fixed period. Gilal (2023) demonstrated that exposing cowpeas infested with *C. maculatus* at a temperature of 60°C for 10 minutes led to the death of all the stages in the life cycle. Some cultures in the past leveraged this technique by placing their grains close to the fireplace, although without a way of regulating temperature and time as is the case with the modern ovens.

4.8 Sun Drying (Solarization)

Solarization takes advantage of the solar heat to warm the infested grains and eliminate or repel the pests. Gebreegziher (2024) points out that although this technique is efficient and cheap, its effectiveness depends on climatic conditions and may not reach large grain masses.

4.9 Chemical Pest Control

Chemical control is another commonly used technique in the management of storage pests, including *C. maculatus*, because of its effectiveness and simplicity. However, with time there have been concerns on resistance development, effects on the environment and human health (Demis & Yenewa, 2022). There have been attempts to look for effective substitutes and proper usage of chemical-based pesticides.

CONCLUSIONS

Callosobruchus maculatus is a major pest of stored pigeon pea, causing significant economic losses through direct feeding, contamination, and degradation of seed quality. The pest's rapid life cycle, driven by environmental factors such as temperature and humidity, enables it to infest stored grains multiple times during a single storage season, exacerbating damage. The infestation leads to weight loss, reduced seed viability, and compromised nutritional value, along with contamination that lowers the marketability and safety of the grains. Effective pest management requires a combination of strategies, including cultural, physical, chemical, and biological control methods, to reduce infestation and prevent further losses. Cultural practices such as proper storage, crop rotation, and intercropping can minimize pest buildup, while physical techniques like irradiation and cold storage offer promising alternatives. However, chemical control methods should be used judiciously to avoid resistance development and environmental harm. A holistic integrated pest management approach is essential for sustainable control of *C. maculatus*, ensuring the protection of pigeon pea crops and contributing to food security and farmer livelihoods in affected regions.

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HOW TO CITE: Athanas Alexander Katoo*, Mathew Ngugi, Stephen Gitahi, Callosobruchus Maculatus: A Biotic Enemy to Pigeon Pea Productivity, Int. J. Sci. R. Tech., 2025, 2 (3), 483-487. https://doi.org/10.5281/zenodo.15085157